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A FRAMEWORK FOR CALCULATING INDIRECT COSTS AND EARNED VALUE FOR IT INFRASTRUCTURE MODERNIZATION PROGRAMS

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A Framework for Calculating Indirect Costs and Earned Value for IT Infrastructure Modernization Programs

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Abstract

Earned Value (EV) supports proactive project management by comparing work accomplished over time against the cost and schedule of work authorized. This comparison is essential to a range of tasks such as performance-based acquisition and budgeting. However, the utility of EV as a planning and management tool depends on the accuracy of Planned Value (PV) estimates. For Information Technology (IT) infra-structure modernization projects, those estimates are dominated by difficult-to-calculate indirect costs—for the effort consumed in communication, control, and coordination activities. While the DoD 5000 recognizes and recommends including indirect costs in Earned-Value computation, it does not provide guidance on how to do so. However, a conceptual framework built around the notion of communications efficiency can be constructed and evaluated using the information resident in artifacts such as Enterprise Architecture products, organizational capability and maturity assessments, and repositories of project data; each of these provide a basis for developing (parametric) bounds on indirect costs and, in some instances, direct estimates. These methods can be built into an Earned-Value Management (EVM) system.

Key Terms: Activity Base Costing (ABC), Capability Maturity Models, CMMI, Indirect-Cost Estimation, Infra-structure Technology (IT) Modernization, Earned Value, Enterprise Architecture, Entropy, Markov Models, Perron-Frobenius Theorem

Introduction: The Problem Context

For knowledge-intensive enterprises such as complex COTS acquisition/integration projects, indirect-cost estimation depends on the capability to understand, manage and control information dependencies. Absence of that capability would create unpredictable consequences to budgets, schedule, risk, and to the performance of acquisition and IT infra-structure modernization programs. Indeed, inaccurate estimates have long plagued these programs. For example, KPMG determined that for 48% of project overruns the root cause was poor planning and estimating (Software Productivity Center). The Standish Group (1995) found the probability of a software project being cancelled increased to over 50% as a direct function of project size,(as measured in function points). In another survey of 8,000 projects in 1995, the Group found that the average project exceeded its planned budget by 90% and its schedule by 120% (Standish Group 1995a; 1995b). In general, the risk of failure for large software projects is significantly greater than for small projects (Humphrey, 2004, p. 25).

But, where disciplined processes are in place, these risks are significantly reduced while productivity is increased. For example, several recent studies of Team Software Process (TSP) showed significant gains in productivity due to tracking of team and individual activity time (e.g.,

for reviews, code development, meetings, defect removal, etc.). This data-driven tracking enabled the identification of activities that added value and of those that did not (Team Software Process (TSP), 2005, 8). It also provides the means to acquire indirect-cost data that is essential to Earned-Value calculations and to Activity-Based Costing (ABC). However, this "bottom-up" approach requires a detailed understanding of organizational activities, resources, and time that may not always be available. In particular, ABC estimates depend heavily on labor-intensive data acquisition (e.g., observing myriad activities, constructing analyses, etc.) which limits the estimates' suitability to projects of limited duration (such as IT modernization). While TSP may be suitable to software development where the key personnel constitute a limited group with strong technical skills, the same cannot be said for complex COTS applications that often involve a wide range of stakeholders.

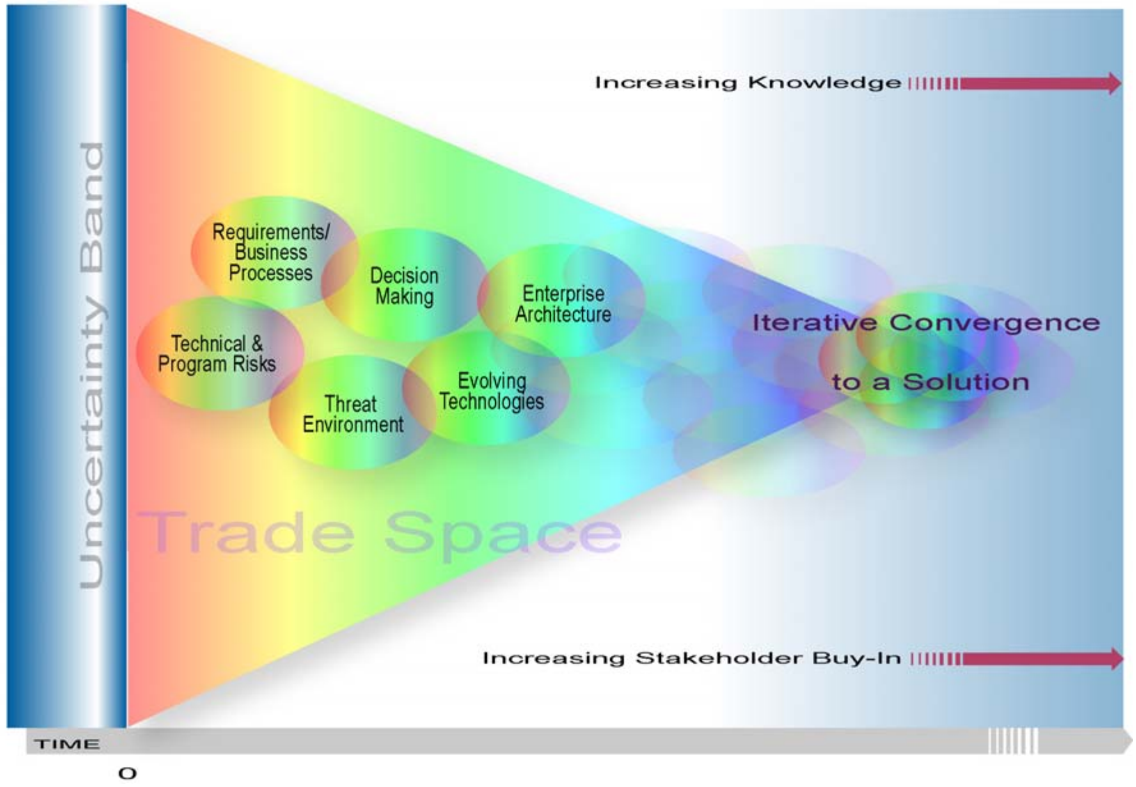
Where a "bottom-up" approach is not feasible, parametric (e.g., statistical) cost estimation can be developed by exploiting artifacts that "should be" available in an IT project environment—such as Enterprise Architecture (e.g., DoDAF) products and data from project repositories. Whatever the approach taken to Earned Value (EV), success depends on effective management control, communications, and coordination. Lacking that basis, EV estimates invariably will be overly optimistic as compared to the actual costs incurred because there is minimal capability to assess "true" project scope. Increases in project size, complexity, scope, volatility, stringent performance requirements (e.g., achieving minimal response latency in networks) all amplify the potential for the distortion of estimates.

The factors influencing indirect costs are myriad, and have differing degrees of volatility and impact over time. These factors include:

> Economies of scale, learning, capacity utilization, system linkages, coordination and control, integration, timing, discretionary policies, location, institutional factors, process maturity levels, learning, geographical dispersion, and team experience.

Various weighting schemes can be developed and applied to these parameters for various classes of models, as will be discussed in Sections 3 and 4, below. Conceptually, Figure 1, below, illustrates the interplay of the factors driving the multi-dimensional complexity facing IT project management.

Figure 1. Program Technology Integration Management



2. Background: Earned Value (EV) and Earned-Value Management (EVM)

EVM is a methodology for assessing project performance in terms of cost and schedule variance over time. It measures work actually accomplished against a schedule for contracted tasks at discrete points in time. By systematically integrating the measurement of cost, schedule, and technical accomplishment EVM, promotes realistic cost-schedule estimates throughout the project's development cycle. Specifically, it integrates three data sources:

(1) Planned Value (PV = BCWS) of work scheduled which defines what is to be accomplished (funding authorized). The challenge is to identify and to measure the indirect costs which consume the vast majority of IT project funds.

(2) Actual Cost of Work Scheduled (ACWS) which defines what is spent—that is, whether anything was accomplished, or not.

(3) Earned Value (EV = BCWP) which measures what was accomplished within the time allowed.

Thus, work packages accepted as satisfactory "earn" the cost of the resources consumed to complete them. The progress of a project can be determined by computing:

- SV = EV – PV
- CV = EV – AC

From these basic relationships, a range of other "dashboard" metrics can be determined as well, such as Estimated Time to Complete (ETC) and Estimate at Completion (EAC).

By determining EV at specific points in time, a project can be assessed against its schedule to determine whether it is "slipping" or not. By capturing the *time value* of information, EV provides Decision Makers with the *predictive capability* that enables flexible response to opportunities afforded by new technologies, evolving conditions, and to joint collaboration requirements—rather than simply reacting to them post facto. That flexibility strengthens overall program/project/portfolio integration and alignment with Agency mission.

3. The Challenge: Computing Indirect Costs

The *management of information* results in the creation of intangible goods and services (e.g., technical advice, activity coordination, stakeholder engagement, training, etc.) that enable a project to converge to a solution, as illustrated in Figure 1. The efficiency of information management governs the rate of convergence to a solution and is influenced by the volatility of factors such as:

- Stake-holder preferences
- Coordination of trade-offs
- Timing of design decisions
- Schedule sensitivity
- Unforeseen side effects of decisions
- Technical and integration complexity
- Architectural insight
- Regulation and policy constraints

How quickly that volatility damps-out depends on factors such as:

- Organizational process maturity (e.g., strong configuration control)
- Ability to manage customer expectations (e.g., proactive stakeholder engagement)
- Overall project-management capability (e.g., as measured by the CMMI, OPM3, 6-Sigma, etc.)

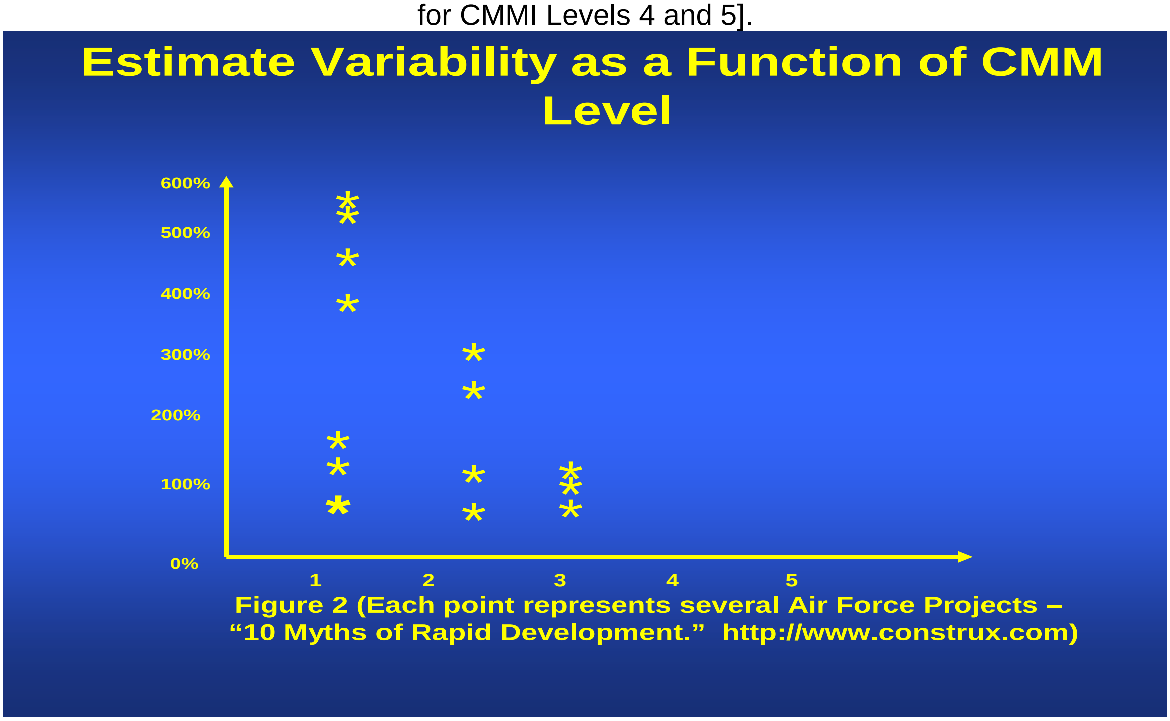
Projects with limited capabilities and processes have difficulty managing this volatility due to:

- Limited coordination and control
- Communications with:
    - ✓ Low information content
    - ✓ Limited accuracy & timeliness
    - ✓ High distortion & error rates

These factors are unlikely to improve over the project life-cycle without changes to overall process and management capability; this unlikelihood is one reason why Fred Brooks observed that “adding resources late to a project makes it later" (1995). There is an important caveat, however; small-scale projects provide environments where face-to-face communications are sufficient for most management, control, and coordination tasks. These conditions make *Agile Methods* feasible for software development. Unfortunately, these agile methods do not appear to scale-up to larger projects with complex integration, change control, program management and coordination requirements.

An abstract representation of key explanatory variables underlying communications efficiency can provide important insight into Planned-Value estimation calculations, thereby contributing to the construction of indirect-cost estimates. In the physical sciences and Information Theory, the measure of communications efficiency is called "Entropy." It is used, for example, to determine how many distinct symbols are required to accurately represent the content of a message. The question before us, however, is not the number of distinct symbols required, but rather the type and extent of processes that must be in place to deliver a required level of communications accuracy (e.g., signal-to-noise ratio gain). In effect, the processes providing these capabilities can be interpreted as “invariants” in a dynamic system. (Without going into detail, entropy serves as a measure of “invariants” in a number of fields, a discussion of which can be found in Lind, D., Marcus, B. (1995). *Symbolic Dynamics and Coding Theory*, Boston: Cambridge University Press). The process invariants of concern to us are provided by process management and improvement methods such as the CMMI, OPM3, 6-Sigma, or their equivalents. As Figure 2 indicates, at least one determinant of estimate variability for IT projects is capability level—this determinant can be used to define worst-case bounds (or confidence intervals) on the accuracy of direct- and indirect-cost estimates.

Figure 2. Estimate Variability as a Function of CMMI Level
[Insufficient data was available at the time of the study to make valid determinations for CMMI Levels 4 and 5].



3.1. Earned Value Dilemmas—For Software Intensive Systems

As Figure 2 suggests, low capability projects are least likely to develop valid estimates. Because they typically have no improvement capabilities, they are unlikely to acquire estimation skills. The problem is compounded by the fact that for IT modernization projects, Planned-Value (PV) estimates are most unreliable early in the project development cycle—when they could provide the greatest benefit—due to factors such as initial instability and uncertainty concerning project scope, requirements, and complexity, and schedule. At the onset of the project development cycle, these factors also will render bottom-up, and labor intensive methods of indirect cost estimation, such as ABC, which are difficult to apply regardless of project maturity level. (The possible exception is organizations with sufficient capability and resources to implement TSP. Of course, the programs resulting from such projects, once deployed of course, could benefit greatly from the application of methods such as ABC.)

However, the Software Engineering Laboratory (SEL) at the NASA Goddard facility has computed cost-estimate variability bounds for CMMI Level-3 projects, the estimated growth in cost projections, and the accuracy of those projects as a function of the project-development cycle. As illustrated in Figure 3, their findings suggest that:

(1) Organizations with at least CMMI level-3capability can (reasonably) project a 40% growth from an initial (under) estimate.

(2) Projects with mature processes can realize significant reductions in estimate uncertainty over the development cycle—increasing confidence in their estimates.

Thus, even though projects may start with similar levels of size, complexity, uncertainty and volatility, those with greater CMMI or similar capabilities can more effectively utilize the information resources at their disposal to drive down estimate variability. Yet, projects with less-mature processes are unlikely to do so, regardless of the methodology employed.

Therefore, whether (and to what extent) a costing method can be effectively employed depends on conditions such as:

- A disciplined process-improvement capability
- Automated Data Acquisition
- Statistical Process Control (SPC)
- A map of information assets (typically provided by an Enterprise Architecture)

These are characteristics of projects with mature process and management capabilities. Figure 3, below, indicates that CMMI level-3 organizations improve their estimates over a project lifecycle by managing their information resources and communications to "learn" throughout the development cycle; in this way, they systematically reduce the uncertainty surrounding virtually all decision variables, including cost estimates.

Figure 3. Cost Estimate Uncertainty Reduction as a Function of

Project Life Cycle and Process Maturity Level

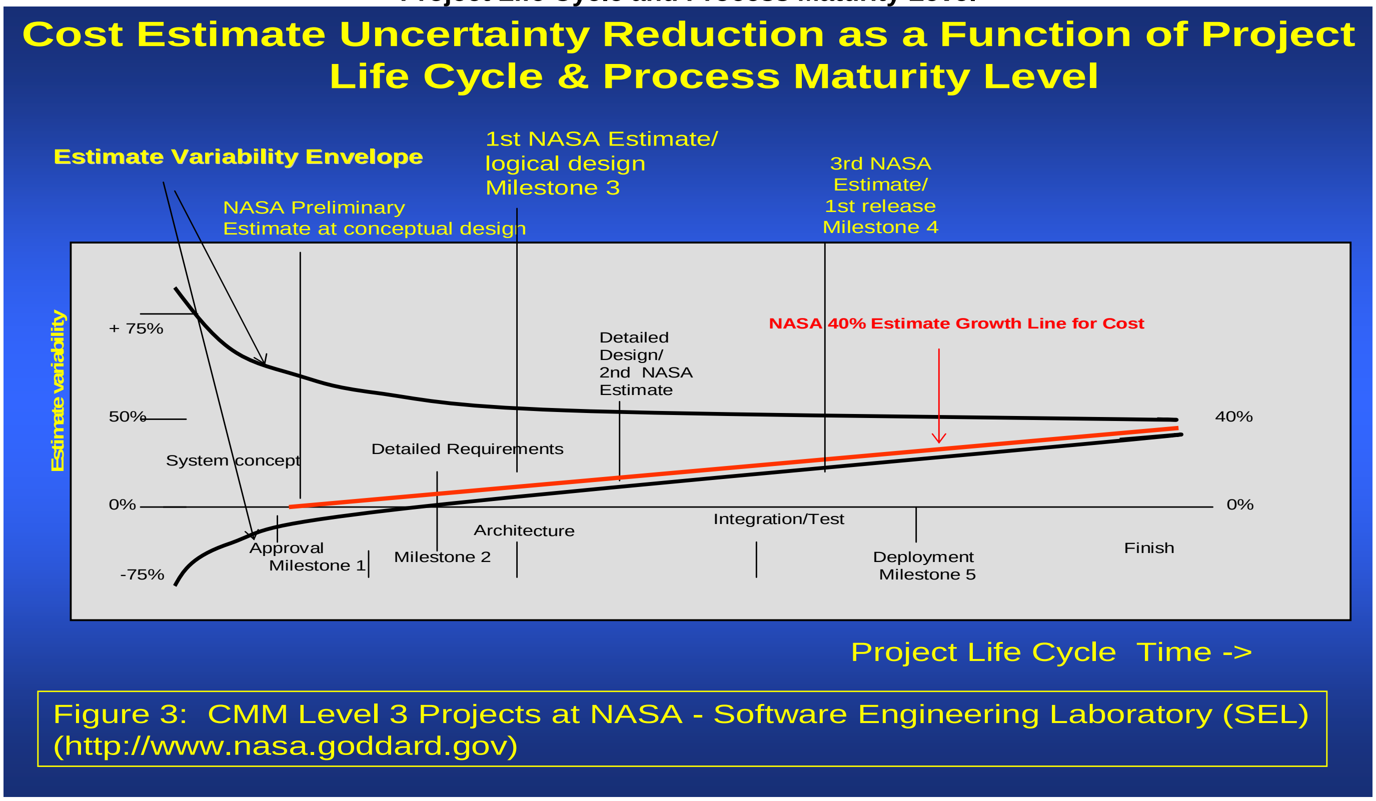


Figure 3: CMM Level 3 Projects at NASA - Software Engineering Laboratory (SEL) (http://www.nasa.goddard.gov)

4. Parametric Modeling of Indirect Costs

Figures 2 and 3 indicate that the ability to reduce the uncertainty envelope is a function of project communications efficiency, which is governed by the factors noted above, such as:

- Project maturity level, complexity, scope, lifecycle stage
- Geographic dispersion
- The volatility of project scope, stakeholder preferences and requirements
- Team experience
- Enterprise Architecture scope and quality

Project information repositories (i.e.,SEL at NASA, Goddard) have data available to assess models that purport to “explain” how these factors act as to drive (down) changes to uncertainty levels. For example, these relationships can be stated more abstractly by letting E(t) represent the level of Entropy as a function of time. Then, these changes can be expressed heuristically as:

[1] dE(t)/dt = f (CMMI Level, EA quality, SPC, 6-Sigma capability, project complexity/scope…)

[2] $dE(t)/dt = a_1x_1 + a_2x_2 + a_3x_3 + \ldots. + a_kx_k + e'$

[3] $\text{Min } E(t) = c_1x_1 + c_2x_2 + c_3x_3 + \ldots. + c_kx_k + e''$

The term ‘e’ represents measurement errors.

For constant a_k, Eqn [2] indicates a constant rate of change over the project lifecycle governed by the capability factors in place. Thus, if the coefficients a_k represent a probability distribution, then Eqn [2] represents a constant rate over time, but is probabilistically distributed.

Eqn [2] assumes that the minimal Entropy level is a linear function of the activities/resources consumed and the associated costs.

While there can be many reasons for questioning the assumptions underlying [1], [2], [3], they nonetheless represent a point of departure for modeling these processes, and they make subsequent analysis mathematically tractable. But, they could be refined to include, for example, non-linear relationships. While this inclusion might improve explanatory power—at least heuristically—it would risk a decrease in mathematical tractability.

Tractability issues aside, Eqns [2] and [3] form a linear optimization problem that can be used to compute cost/schedule estimates and other dashboard metrics which are subject to constraints defining the structure of the project (as determined by architectural and workflow detail, resource availability, etc.). Eqns [2] and [3] have the effect of directly integrating objectives and constraints; Decision Makers could quantitatively assess the value of the information provided by disciplined processes against a range of "what-if" scenarios of scope, cost, performance, schedule and risk trade-offs over a project's lifecycle by utilizing these equations. Other possibilities for extension and refinement include introducing time as a variable, which would transform Eqns [2] and [3] into a control-theory problem.

These simple models provide qualitative insight into organizational processes, information dependencies and their impact on overall estimation capability. For example, Figures 2 and 3 qualitatively suggest that:

- Declining rates of estimate variability and uncertainty decrease entropy for high capability organizations (CMMI, OMP3, 6-Sigma, etc.). That is,

  [2] $dE(t)/dt < 0$

- Constant or increasing estimate variability for less capable organizations. That is,

  [2] $dE(t)/dt \geq 0$

4.1. The Perron-Frobenius Theorem

If the transition matrix ***P*** is irreducible, and a-periodic, then $\boldsymbol{P}^k$ converges (element-wise) to a matrix in which each column vector is the unique stationary distribution **π'**, independent of the initial distribution $\boldsymbol{\pi}^0$.

$$[4] \quad \lim_{t \to oo} \boldsymbol{\pi}' = \boldsymbol{\pi}^0 * \mathbf{P}$$

Where:

Irreducible means that all elements of the matrix are non-negative.

A-periodic means no looping among states (system movement among states does not result in a periodic sequence such as: 1-2-5… 8-20 … 1-2-5 …).

Ergodic means that for an irreducible Markov Chain, a limit exists and is independent of "k" (some initial state for the system).

[4’] lim p_{kj} (n) = π_j, n = 0, 1,2, 3,....   (discrete time intervals)

That is to say, after a large number of transitions, the probability of the transition from state “k” to state “j” is independent of “k”, where these states could represent different values of a performance metric. In a project context, the states could represent the number of open-action items, the processing time required to complete a transaction, etc. Thus, the long-run rate of improvement π_j could be computed from time-series data, and could be interpreted as the ‘a_k’ of Eqn [2]; this, in conjunction with Eqn [3], could be used to determine a range of risk values subject to a set of constraints—for example, on scope, cost, schedule, resources, etc.

If the convergence process of Eqn [4] is Markovian, the value of the current state of a system at time “n” is dependent only on the state of the system at time “n-1,” and on no prior states “n-2,” “n-3,” etc. Thus, if the variable of concern is estimate accuracy, then its value (state) depends only on the accuracy of the estimate in the preceding time period. Of course, by the time a limiting value is reached, a project could be long since completed, have incurred multiple changes in scope, etc.

Nonetheless, Eqn [4] is significant because it quantitatively integrates project scope, complexity and other key parameters in the matrix **P**, with the capabilities and controls available to management in the vector **π**. Those capabilities are largely a function of its maturity/capability level, as measured by standards such as the CMMI, OMP3, 6-Sigma, etc. Those capabilities are relatively stable overtime, thus giving rise to the (relatively) constant rates for the vector **π**. The product of the interactions of **P** and **π** can be used to estimate a range of factors of interest to Decision Makers—assuming, of course, that valid data is available.

The matrix **P** can be interpreted as a matrix of probabilities describing the likelihood of a project being in a state defined by values for project scope, complexity, technical challenge, team geographic dispersion, work flow and sequencing dependencies, training levels, etc. In principle, this information is available from sources such as Balanced Score Cards, Enterprise Architectures, Work Breakdown structures, Subject Matter Expert opinion, various assessment and analyses, project data repositories, etc.

Per Eqn [4], the different capability levels represented in **π** will produce different rates of convergence for the bounds on the uncertainty surrounding parameters such as the reliability of cost or schedule estimates. Per Eqn [2], Figures 2 and 3, project with low capability levels are unlikely to drive down the level of uncertainty, while more mature projects will do so- and overtime improve their estimation capabilities - in no small part as a consequence for their underlying communications efficiency.

5. Change Effects and Indirect Cost Estimation

The larger the amount of new technology to be integrated and/or modified, the larger the risk of schedule and cost creep due to factors such as rework and overall under-estimation of the complexity. These considerations are particularly important for estimating the level of effort and costs associated with the integration of, or modification to, large-scale legacy systems and COTS applications. The following diagram illustrates these considerations.

Figure 4: "As-Is" Financial Architecture of a Major Government Agency

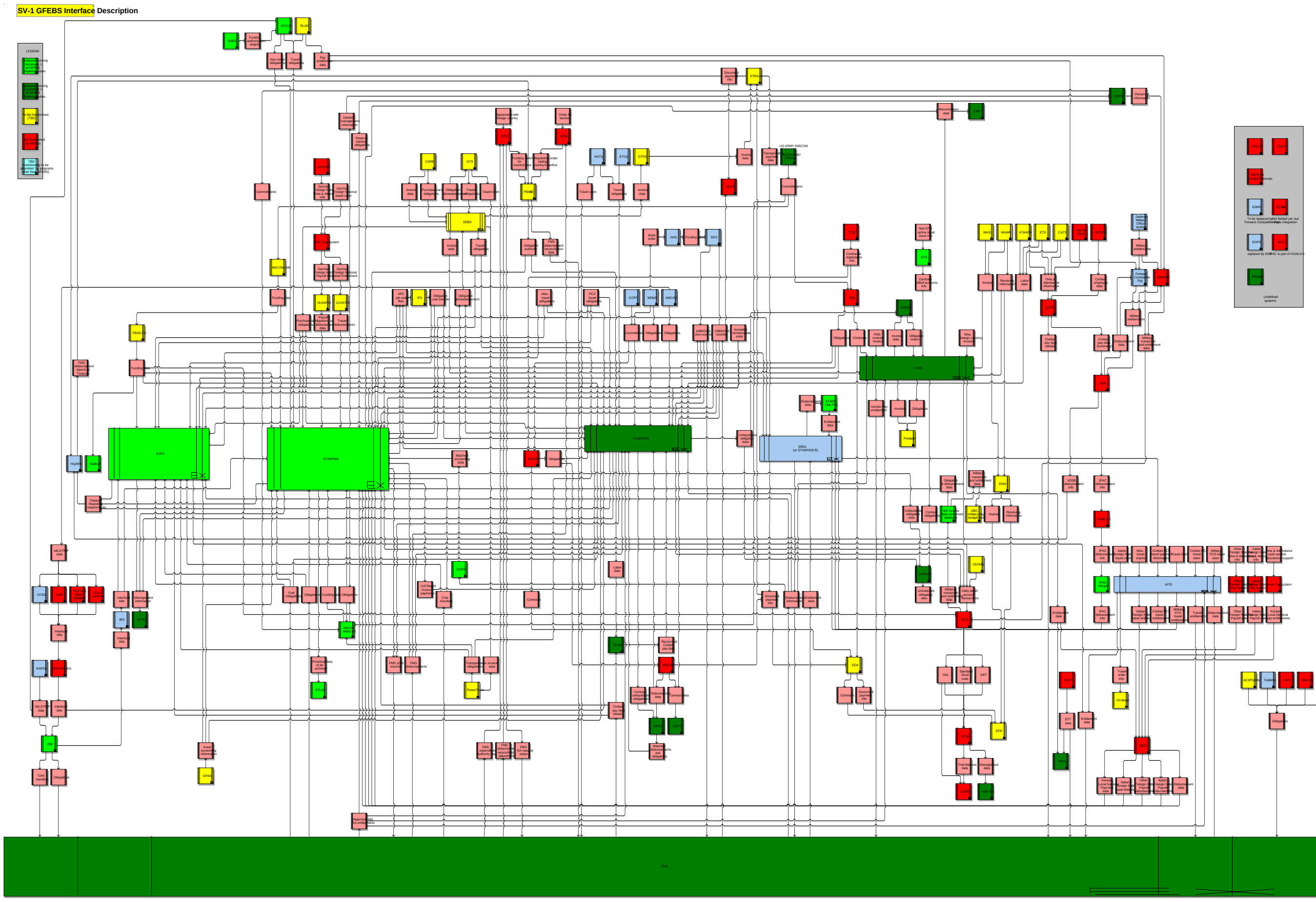


Figure 4 illustrates how cost under-estimation can occur, especially in organizations with low communications efficiency (e.g., the capability to systematically engage stakeholders, technical staff, users, etc.) and minimal architectural insight (e.g., the capability to construct a system-connectivity map such as Figure 4). It also illustrates why life-cycle maintenance costs can be far higher than in the initial development cost. Without these capabilities, the risk of unforeseen and expensive side effects is high. However, with improved capability levels, the ability to acquire and to use a range of information sources—and, thus, the ability to identify the scope of secondary effects, the associated cost, schedule, and scope impacts—improves. The information and data acquired could be applied using Eqn [4], the output of which could then be used to develop the constrained optimization formulation of Eqns [2] and [3] for assessing risk, technical and programmatic performance resulting from investments in various capabilities across a range of "what-if" planning scenarios.

5.1. Applications to System Test Coverage

These models could also be used to help quantify the scope and cost of testing for IT modernization programs. Those costs are always major portions of an IT budget, and there is no satisfactory means to answer the question "how much is enough?" Without going to detail, these equations could be used to estimate test coverage requirements such as:

- The number of modules requiring modifications

- The complexities of the modules requiring modifications
- The availability, accuracy, completeness of the specifications of the modules requiring modification
- The degree to which modifications in a module cause modifications in other modules (i.e., secondary ripple effects that can have significant cost or schedule impact as is illustrated below)
- The impact to the reliability of the System

For example, an estimate of the impact of changes to systems with (probable) dependencies on other systems comprising an application and the Total Expected Number of Changes (**T)** can be computed using:

[5] $\mathbf{T} = \mathbf{A}*(\mathbf{I} - \mathbf{P})^{-1}$

(A discussion of Eqn [5] and its relationship to the previous equations can be found in any standard text on Stochastic Processes or Operations Research.)

I is the identity matrix

A is a matrix of initially planned changes

P is the matrix of probabilities of changes that will impact additional systems. These changes will arise from a range of project-specific structural factors as well as technical and programmatic dependencies that can be determined from sources such as DoDAF Enterprise Architecture products:

- OV-3 Operational-Information Exchange Matrix
- SV-1 System-Interface Description
- SV-6 System Data-Exchange Matrix

These artifacts enable the determination of the location and structure of dependencies that create high coupling (e.g. lots of poorly documented, ad hoc interfaces) and low cohesion (software functionality not organized for efficient utilization or maintenance) which are typical of (patchwork) legacy systems.

5.2 Modeling Change Propagation Effects—A Simple (Hypothetical) Example

- Make two changes to module M1 and one change to module M3.
- The question is how many secondary changes will be generated before the ripple effect dies out.

M1

**/ **

M2 M3

Assumptions:

- For any change to a module, there is a 10% chance of having to make another change to the same module.
- For a change Module M1, there is a 20% chance of having to make changes to modules M2 and M3.
- Changes to M2, M3 do not affect other modules.

Table 1. Initial Change Matrix for a (Hypothetical) Simple System

A =

Module	**# of Changes**
M1	2
M2	0
M3	1

Table 2. Probability Connection Matrix

P =

	M1	M2	M3
M1	.1	.2	.2
M2	0	.1	0
M3	0	0	.1

Total Expected Number of Changes (T)

[4'] $T = \mathbf{A}*(\mathbf{I} - \mathbf{P})^{-1} = 4.31$

So, the 3 initial changes result in somewhat over 4 changes being made before the ripple effect dies out.

5.3 - Modeling Change Propagation Effects—A More Complex Example

What would happen if we applied the above model to a system such as presented in Figure 4?

As the following Table illustrates, the result can be significant.

Table 3. Change Probabilities—A More Complex (Hypothetical) Example

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.2	0.1	0	0	0	0.1	0	0.1	0	0.1	0.1	0.1	0	0	0	0.1	0	0
2	0	0.2	0	0	0.1	0.1	0.1	0	0	0	0	0	0.1	0.1	0.1	0	0.1	0
3	0	0	0.1	0	0	0	0	0	0.1	0	0	0.1	0	0	0	0	0	0
4	0	0.1	0	0.2	0	0.1	0.1	0.1	0	0	0	0	0	0	0.1	0	0.1	0
5	0.1	0	0	0	0.4	0.1	0.1	0.1	0	0	0	0	0	0	0	0	0.1	0
6	0.1	0	0	0	0	0.3	0.1	0	0	0.1	0	0	0	0.1	0	0.1	0.1	0
7	0.1	0	0	0.1	0.2	0.1	0.3	0.1	0	0.1	0	0	0	0.1	0	0	0.1	0
8	0.1	0.1	0	0.1	0.2	0	0.1	0.4	0	0.1	0	0	0	0.1	0	0	0	0.1
9	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0
10	0.1	0	0	0	0	0.1	0.1	0.1	0	0.4	0.2	0.1	0	0.1	0.1	0.1	0.1	0.1
11	0.1	0	0	0.1	0	0	0	0	0	0.2	0.3	0.1	0.2	0	0	0	0	0
12	0.2	0	0	0	0	0.1	0	0	0	0	0.2	0.3	0	0	0.1	0.1	0	0.1
13	0.1	0.1	0	0	0	0.1	0.1	0.1	0	0.2	0.1	0	0	0.2	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.2	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
18	0	0	0	0	0.1	0	0.1	0	0	0.1	0	0	0	0	0	0	0	0.3

Table 4. The Change Propagation Impact in a More Complex System

Module #	Initial change A	Total Change $T = A*(I - P)^{-1}$
1	2	242
2	8	101
3	8	4
5	28	249
6	12	230
7	8	229
8	28	257
9	4	4
10	8	319
11	40	239
12	12	131
13	16	128
14	12	157
15	296	2961
16	28	150
17	28	188
18	40	139
Total	**296**	**2961**

5.4- Discussion

Table 3 shows that for a 296 initial changes, there is a *ten-fold increase* in the total number of changes to the system which, if not accounted for, will derail resource planning, cost and schedule estimates. The probabilities in the above Table are conservative. For poorly documented legacy systems, the probability dependencies could be much more numerous and more likely. Such effects can be expected for poorly documented/engineered legacy systems that accumulate a large number of patches over the years and which result in a much larger-than-anticipated number of (costly) ripple effects. Improvements that benefit estimation also benefit many other project components. Accordingly, low maturity/capability projects lack the structural pre-requisites for efficient/timely communication; they cannot marshal relevant information and resources to identify or to manage these effects. Thus, estimates are typically off by orders-of-magnitude.

6. Conclusion and Next Steps

For large scale (DoD) projects with hundreds of stakeholders, hundreds or thousands of (sub) systems, users and stakeholders deployed globally at a large number of different sites, the risks of under estimation are correspondingly greater. Mitigating those risks depends on the efficiency of project/program communications, which is closely related to overall project maturity level.

The framework outlined here proposes to use the equations such as [1] - [5] outlined above to measure the outcomes of project-management/organizational effectiveness as a consequence of the interactions between the capabilities provided at different maturity levels and project characteristics such as scope and complexity. To make these equations useful estimation tools, project data repositories such as those of NASA/SEL, NIST, and others, will be investigated to develop “realistic” parameter values, model relationships, and confidence levels.

Once validated, the models can be used to:

- Calculate indirect costs for inclusion in EV calculation, with confidence-interval estimates defined in terms of the interactions between project complexity and capability levels
- Add the dimension of project communications efficiency to risk management
- Use the models, in conjunction with “what-if” scenario-capable Enterprise Architecture tools (such as Metis) to provide both qualitative and quantitative insight into the effects of trade-offs, mitigation strategies, and project-improvement initiatives
- Provide conceptual insight into the communications efficiency of various organizational models
- Embed the models in a larger Planning Programming Budgeting Execution (PPBE) and Portfolio Management framework and apply to tasks such as understanding the cost, scheduling implications project/program alignment with Agency mission, prioritizing, stabilizing, and managing joint requirements, stakeholder preferences, and assessing the effectiveness of “horizontal integration” initiatives.

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